

Routine Operating Procedure

LANSCE-3-ROP-20

WNR Target-4 Nuclide Inventory Control

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Originated:  7-22-02
Bruce Takala, LANSCE-3

Concurrence:  8-6-02
Ivan Trujillo, DOE Facility Representative

Approved:  7/22/01
C. John Graham, LANSCE Safety Manager

 7/22/02
Steve Wender, LANSCE-3 Group Leader

 7/23/02
Floyd Gallegos, LANSCE-6 Group Leader

 7/22/02
Dan Seely, TA-53 Facility Manager

 9/26/2002
Kevin Jones, LANSCE Deputy Division Director for Operations

1.0 Introduction and Purpose

Target-4, a tungsten spallation neutron source used for basic, applied, and defense-related research, is operated by LANSCE-3. Bombardment of the target by the primary proton beam produces neutron beams, but also causes activation of the target. Recent calculations using the MCNPX and CINDER computer codes indicate that nuclide activation levels in Target-4 could approach the Category-3 threshold (TQ3) for a nuclear facility unless adequate controls are established. The purpose of this document is to establish administrative requirements and controls to prevent Target-4 from exceeding the TQ3 threshold without authorization.

The goal of this document is to set limits that will keep the nuclide inventory of targets stored or used in WNR Target-4 to less than 0.6 TQ3, as calculated by the MCNPX/CINDER code systems.

Two targets may be installed in the Target-4 vacuum chamber, but only one can be irradiated at a time. If two targets are present in Target-4, the TQ3 shall be based on the sum of the inventories in each target.

To ensure that the present nuclide inventory does not exceed 0.6 TQ3 during operation, limits on the beam current and integrated beam current to Target-4 will be established. Anytime the total inventory exceeds 0.6 TQ3, operation of Target-4 is not authorized except through an accepted DOE authorization basis process.

2.0 Scope

This document on nuclide inventory control applies to WNR Target-4 at LANSCE.

3.0 Requirements

3.1 Target-4 Nuclide Inventory Calculations

Prior to delivering beam to WNR Target-4 at the start of each run cycle, and at least annually during that run cycle, the nuclide inventory of Target-4 will be calculated and the fraction of the TQ3 determined using the computer codes MCNPX and CINDER. This calculation will be based on the irradiation history of the target as recorded by LANSCE-6. *Note: A single run cycle contains periods of scheduled beam delivery interspersed with periods designated for activities such as source recycle, periodic maintenance, and required equipment checks.* At present, typical run cycles are 6-8 months.

In addition, the amount of additional beam (integrated beam current) delivered to Target-4 that would result in a nuclide inventory of 0.6 TQ3 will be calculated. This calculation will be based on continuous delivery of scheduled beam at a constant beam current. The beam current used in this calculation is determined by LANSCE-3, based on operational and experimental needs and shall become the Maximum Beam Current Operating Level for operation of Target-4.

These calculations shall be performed by personnel with demonstrated competency with these codes and shall be peer-reviewed. The results of these calculations will be documented in a report addressed to LANSCE-3, with a copy sent to LANSCE-FM and the DOE Facility Representative.

Note: the nuclide inventory calculations are not expected to include any factors to account for the uncertainty of the activation cross sections or for nuclides which do not have Category-3 ratios.

3.2 Beam Delivery Controls

Based on the results of the nuclide inventory calculations, LANSCE-3 will establish the following administrative controls on beam delivery to Target-4.

3.2.1 Maximum Beam Current Operating Level

A Maximum Beam Current Operating Level shall be established. This operating level shall be the beam current used in the nuclide inventory calculations to determine the amount of additional beam delivered to the target that would result in a nuclide inventory of 0.6 TQ3.

The Maximum Beam Current Operating Level is not a current limit, but rather a beam current target. Minor excursions due to tuning or normal drift of accelerator components are allowed.

Basis: The nuclide inventory calculations for Target-4 show that only two isotopes contribute significantly to the TQ3, Gd-148, (75 year half-life), and I-125, (60 day half-life). Combined, these nuclides comprise more than 75% of the Category-3 ratio after several months of continuous operation. Because of their relatively long half-life, short periods of beam operation in excess of the beam current operating level will not cause a significant increase in the activity of these nuclides.

3.2.2 Integrated Beam Current Limit

An integrated beam current limit will be established for Target-4. This limit shall be equivalent to the amount of additional beam delivered to the target that would result in a nuclide inventory of 0.6 TQ3, as determined by the nuclide inventory calculations. Beam operations to Target-4 shall cease before the total beam delivered to Target-4 reaches the integrated beam current limit.

These administrative control levels shall be in effect during the entire beam delivery period unless reassessed in accordance with this procedure.

These administrative control levels shall be reevaluated annually during beam operation and prior to each beam delivery period.

These controls on Target-4 beam delivery shall be communicated to the operations group (LANSCE-6) for implementation. LANSCE-6 is responsible for ensuring that these controls are met during beam operation.

Establishment and implementation of these controls prior to resumption of beam operations shall be confirmed by sign-off of the Target-4 section of the master administrative check schedule.

Basis for the controls: The nuclide inventory in Target-4 is determined by the irradiation history of the target. This inventory can be bounded by establishing controls on the beam current and the integrated beam current delivered to the target. Nuclides with short half-lives as compared to the irradiation time establish equilibrium between production and decay, and thus have an activity that is directly proportional to the beam current. Nuclides with very long half-lives do not decay appreciably during the irradiation time. Their activity is proportional to the integrated beam current. The activity of nuclides with half-lives between these two extremes are influenced by both factors.

The maximum nuclide inventory is calculated by assuming 100% availability of maximum beam during scheduled run periods. Any interruption of beam delivery will result in less production of radionuclides in the target. Because 100% availability of beam to Target-4 is highly likely, the actual nuclide inventory will be less than the maximum inventory calculated based on continuous operation.

The beam delivery controls established in this section are independent of the beam operations schedule. As long as Target-4 is operated within these established control limits, the 0.6 TQ3 inventory limit will not be exceeded, independent of when the beam is delivered.

3.3 Target-4 Irradiation History

A record of the beam irradiation history for Target-4 shall be collected and documented. This record will be used to show compliance with the established controls, and can be used as a basis for subsequent nuclide inventory calculations.

The Target-4 irradiation history will be maintained by LANSCE-6.

4.0 Responsibilities

The responsibilities for implementing this document are assigned to the following groups:

4.1 LANSCE-3

- ensure that the nuclide inventory calculations are performed as required

- establish the beam current operating level and integrated beam current limit for Target-4
- keep track of the total amount of beam delivered to Target-4 during the beam delivery period
- instruct LANSCE-6 to cease delivery of beam to Target-4 before the integrated beam current limit is reached

4.2 LANSCE-6

- deliver beam to Target-4 only if the beam current operating level and integrated beam current limit have been established and implemented
- ensure that the average beam current to Target-4 remains within the limits established by LANSCE-3
- provide Target-4 beam current data integrated over regular intervals to LANSCE-3
- document and maintain the Target-4 irradiation history

4.3 LANSCE-FM

- ensure that inventory calculations have been reviewed by competent personnel
- concur that beam may be delivered to Target-4 based on evidence that established controls will keep the Target-4 nuclide inventory below 0.6 TQ3
- ensure that these requirements are included in the LANSCE Safety Analysis Document and the TA-53 Facility Safety Plan as appropriate.